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The first survey on harvestmen in Brazilian artificial cavities, with notes on distribution and natural history

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Abstract

Several species of harvestmen occur in natural subterranean cavities using these habitats as shelters and sites of oviposition. Many species have evolved in these environments, thus becoming cave-dwellers. In a few cases harvestmen have been reported in artificial cavities (mines), but without details about their distribution or natural history. Based on faunal inventories carried out in 111 artificial cavities in the state of Minas Gerais, Brazil, this work aimed to register species of harvestmen that are associated with these artificial cavities. Seventeen species were found in 12 municipalities, in addition to new occurrences for 14 of these species and some new behavioral notes. Two undescribed species were also recorded. This study highlights that artificial cavities may be used as shelters by harvestmen, mainly in human-modified landscapes.

Keywords

Opiliones, artificial subterranean cavities, mines, new records, aggregation, Neotropical, Brazil

Introduction

Subterranean cavities can be formed by the action of environmental agents (e.g. water action and eruptions) (Allred and Allred 1997, Culver and Pipan 2009) or anthropogenic activities (Peck 1988, Bernardi et al. 2010, 2011, Isaia et al. 2011). Some natural cavities (paleo-burrows) were also made by the activity of large mammals extinct during the Pleistocene (Buchmann et al. 2009).

Natural subterranean cavities (karstic caves) are originated mainly by the dissolution of rock through water action, thus forming galleries (Ford and Williams 2007). In contrast, artificial subterranean cavities are generated by human action with the intention of extracting minerals or metals of economic value, for the construction of structures such as access tunnels or even for military purposes (Peck 1988, Bernardi et al. 2010, 2011, Isaia et al. 2011).

Although natural and artificial cavities present different genesis, these habitats may have similar environmental characteristics, which are primarily determined by the permanent absence of light, limited food, constantly high relative humidity and thermic stability (Ferreira 2004, Culver and Pipan 2009, Bernardi et al. 2010, 2011, Isaia et al. 2011). These environmental similarities generally enable a similar faunistic composition in these two systems (natural and artificial cavities) (Peck 1988, Ferreira 2004, Bernardi et al. 2010, 2011) in the same region. In this context, several taxa are common to both habitats, such as amphibians, arachnids, bats, crickets, moths and a large number of other invertebrates (Peck 1988, Gnaspini and Trajano 1994, Ferreira 2004, Bernardi et al. 2010, 2011, Isaia et al. 2011, Rosa and Penado 2013, Kurta and Smith 2014, Ueti et al. 2015). Among these groups, the members of the order Opiliones are also a common component inside natural and artificial cavities.

The order Opiliones Sundevall, 1833 is divided into four extant suborders, comprising 49 families and 6519 species worldwide (Kury 2011), representing the third most diverse group in the class Arachnida. In Brazil, there are 855 described species (Kury 2003). Epigean species of this order can be found in the soil, moss, leaf litter, under rocks, tree barks, stone walls, under the vegetation and in caves (Machado et al. 2007). The vast majority of species is nocturnal and need high levels of humidity to survive (Machado et al. 2007). This last condition is generally found both in natural (Culver and Pipan 2009) and artificial cavities (Peck 1988, Ferreira 2004, Bernardi et al. 2010, 2011, Isaia et al. 2011). Many harvestmen species use caves as shelters, where they may lay eggs and raise offsprings, and are often found in large aggregations on the cave walls. These species are classified as trogloxenes (e.g. *Mitogoniella indistincta* Mello-Leitão, 1936, *Serracutisoma spelaeum* (Mello-Leitão, 1933)). There are also troglophile species that may remain inside the cavities to complete their life cycle (e.g. "*Daguerreia inermis*" Soares & Soares, 1947, *Pararezendesius luridus* H. Soares, 1972). The two previously conditions may be facultative, while the troglobitic species are exclusively found in caves and generally present morphological modifications, such as eye reduction, depigmentation and elongation of legs, which are considered adaptations to subterranean conditions (e.g. *Spinopilar moria* Kury & González, 2008, *Giupponia chagasi* González & Kury, 2002).

It has been shown by several studies that caves are natural shelters for many epigean harvestmen species (Ferreira et al. 2005, DaSilva and Gnaspini 2010, Chelini et al. 2011). However, few studies registered the presence of these arthropods in artificial cavities in Brazil (Gnaspini and Trajano 1994, Bernardi et al. 2010, 2011, Ázara et al. 2013) and worldwide (Holmberg et al. 1984, Angerilli and Holmberg 1986, Moseley and Hebda 2001, Isaia et al. 2011). This is probably due to the small number of faunal surveys conducted in these environments when compared to natural caves (Trajano and Bichuette 2010, Reboleira et al. 2011, Silva et al. 2011a, Silva et al. 2011b, Iniesta et al. 2012, Pellegrini and Ferreira 2012, Simões et al. 2014, Silva et al. 2014, Silva and Ferreira 2015).

Considering the small number of faunal surveys performed in artificial subterranean cavities, the present study aimed to: (i) register harvestmen species associated with artificial cavities in Minas Gerais state, Brazil and (ii) present data regarding the species distribution, new occurrences and presence of aggregations in these environments.

Methods

A total of 111 subterranean artificial cavities were sampled in 13 municipalities in the state of Minas Gerais, Southeast Brazil. Each municipality is shown in Figure 1 indicated by a letter in brackets: Alagoa (a, 2 cavities), Ataléia (b, 1 cavity), Caeté (c, 4 cavities), Caraí (d, 17 cavities), Mariana (e, 11 cavities), Mateus Leme (f, 4 cavities), Medina (g, 13 cavities), Nova Lima (h, 1 cavity), Novo Oriente de Minas (i, 7 cavities), Ouro Preto (j, 4 cavities), Padre Paraíso (k, 30 cavities), São José da Safira (l, 16 cavities) and Vazante (m, 1 cavity) (Figure 1). Pictures from some of the surveyed cavities are displayed in Figure 2. This study was based on data obtained through direct observations from the fieldwork and on a literature review to search for additional information about the records of harvestmen species.

Among the sampled municipalities, Alagoa, Ataléia, Caeté, Caraí, Mariana, Mateus Leme, Medina, Nova Lima, Novo Oriente de Minas, Ouro Preto, Padre Paraíso and São José da Safira are in the Atlantic Forest biome; Caeté and Nova Lima are situated in the transition between Cerrado and Atlantic Forest, while Vazante is located in the Cerrado (IBGE 2004) (Figure 1). However, most of the cavities were located in modified landscapes of these biomes, which were mainly surrounded by pastures. All collections were performed between April 2008 and November 2009.

The original names of the artificial cavities, most of them given by local residents, were maintained since there is no agency in Brazil responsible for the registration of these habitats. Besides, many names refer to the location of the cavities, what might be a helpful tool to find the locality. Since all the artificial cavities of this study are mines we will use further the term mines.

The specimens found in the mines were sampled with the aid of tweezers, after a detailed and extensive search. In order to assess the position of the species in the cavities, each observed individual was plotted in a schematic map of the mine according to the methodology proposed by Ferreira (2004). After the survey, information about the abundance

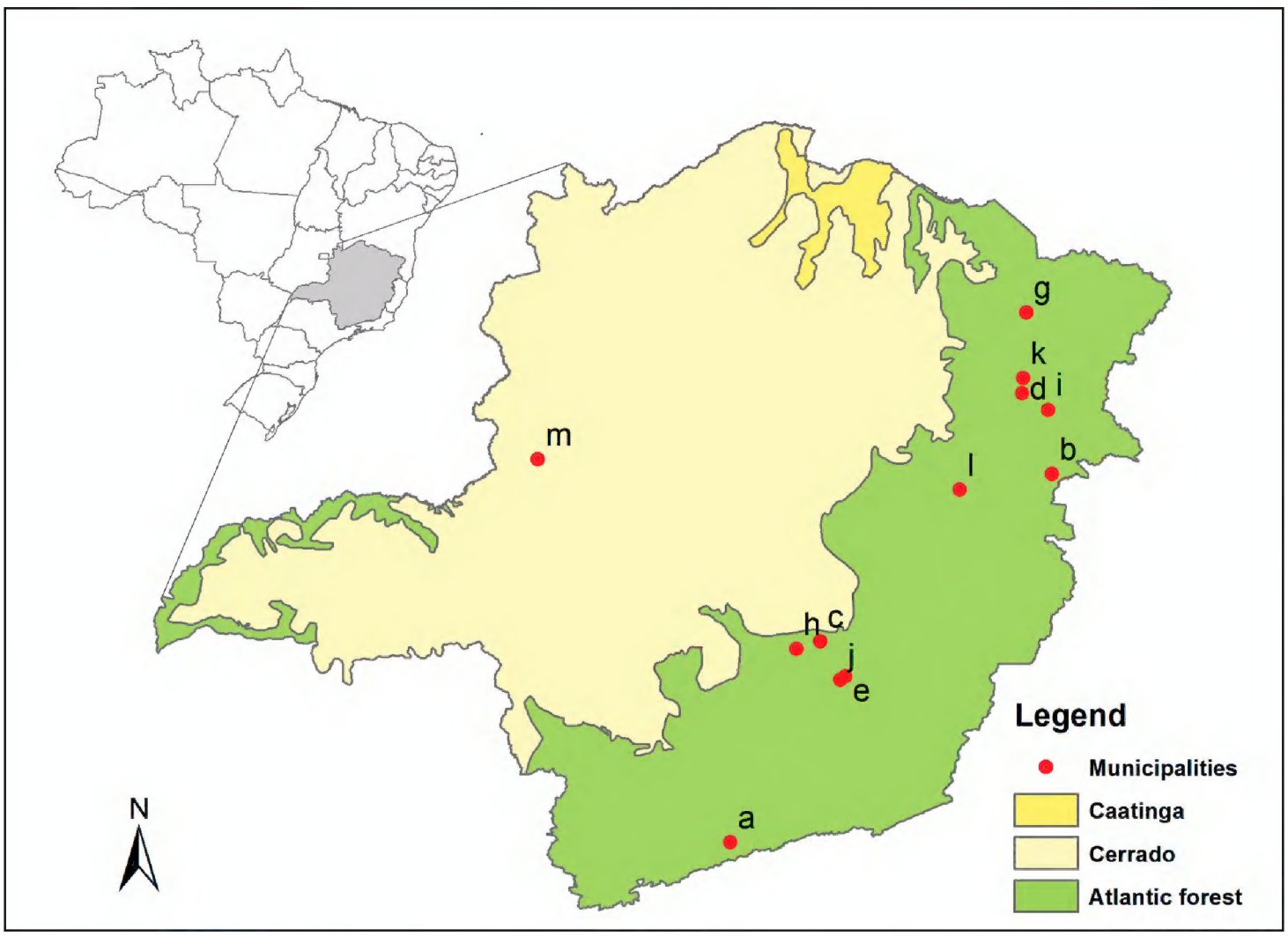

Figure 1. Map of the state of Minas Gerais, Brazil, showing the biomes and municipalities in which the artificial cavities are situated: **a** Alagoa **b** Ataléia **c** Caeté **d** Caraí **e** Mariana **f** Mateus Leme **g** Medina **h** Nova Lima **i** Novo Oriente de Minas **j** Ouro Preto **k** Padre Paraíso **l** São José da Safira **m** Vazante.

and distribution of each species were obtained. In addition, the presence of loose aggregations was recorded, which were represented by groups of three or more individuals with their bodies between 0 to 5 cm apart from each other with their legs overlapping, such as proposed by Machado et al. (2000) and revised by Machado and Macías-Ordóñez (2007).

Individuals were identified whenever possible. In cases of nymphs, females and undescribed species, the individuals were just separated into morphospecies. However these morphospecies were theoretically considered as species. When there was more than one morphospecies in the same genus, they were separated using correlative numbers.

To determine the extension of the aphotic zone, a luximeter was positioned 1.2 m above the ground with its reception cell directed to the cavity entrance. The device was then conducted from the entrance to the interior of the subterranean system. The location where the luximeter presented luminosity equal to zero was considered the transition between the aphotic and the photic zone.

Specimens were deposited in the Collection of Subterranean Invertebrates of Lavras (ISLA) at the Federal University of Lavras, Lavras, Minas Gerais, and in the National Museum of the Federal University of Rio de Janeiro (MNRJ), Rio de Janeiro, both in Brazil.

The occurrences of harvestmen species are indicated in alphabetical order in the results with the abundance of each species in each locality indicated in parentheses.

Figure 2. Artificial cavities in: **A**, **B**, **C** Alagoa **D** and **E** Padre Paraíso **F** Caraí **G** Mariana **H** São José da Safira **I** Caeté **J** Mariana.

Results

From all the 111 sampled mines 52 contained harvestmen distributed in 12 municipalities (Figure 1). Overall 6,066 individuals were observed, which belong to 17 species, 10 genera, 7 subfamilies and 4 families. We found different distribution and abundance patterns: from species with just one individual (e.g. *Paratricommatus* sp. 1, *Goniosoma carum*, *Pseudopucrolia mutica* and *Eusarcus* sp. 2) to broadly distributed and abundant species (e.g. *Mitogoniella indistincta*) presenting more than 500 individuals in 4 municipalities and 21 mines (Table 1).

The following species and genera were new occurrences for the state of Minas Gerais (letters in brackets correspond to the municipality): *Abaetetuba bahiensis* (g), *Gryne perlata* (d, g, k), *Paratricommatus* sp. 1 (c), *Spinopilar* sp. 1 (f), *Goniosoma carum* (j), *Goniosoma vatrax* (h), *Liogonyleptoides inermis* (i), *Pseudopucrolia mutica* (d), *Longiperna trembao* (c, e), *Mitobatula* sp. 1 (a), *Eusarcus aduncus* (c, l), *Eusarcus cavernicola* (m), *Eusarcus* sp. 1 (e, l), *Eusarcus* sp. 2 (f) and *Planiphalangodus* sp. 1 (a). Additionally, this study improved the information about the distribution of some species, such as *Goniosoma vatrax* with about 40 km, and *Gryne perlata* with 1000 km. It was also registered for the first time an aggregation behavior for *Abaetetuba bahiensis* and *Gryne perlata*, besides the record of two undescribed species.

Table 1. Distribution of harvestmen species in the municipalities and mines with information about their total abundance and presence (P)/absence (A) in aphotic and/or photic zones. *The abbreviated name of the species will be used to refer to each species in Table 2. The symbol "-" means the absence of data. N = abundance.

Abreviated name of the species	Species	N	Family	Municipality	Mine	Aphotic zone	Photic zone
Ab. b.	*Abaetetuba bahiensis* (Mello-Leitão, 1931)	66	Sclerosomatidae	g	4	A	P
Gr. p.	*Gryne perlata* Mello-Leitão, 1936	5298	Cosmetidae	d, g, k	11	A	P
Pa. 1	*Paratricommatus* sp. 1	1	Cryptogeobiidae	c	1	-	-
Sp. 1	*Spinopilar* sp. 1	3	Cryptogeobiidae	f	1	-	-
Go. c.	*Goniosoma carum* (Mello-Leitão, 1936)	1	Gonyleptidae	j	1	-	-
Go. v.	*Goniosoma vatrax* Koch, 1848	14	Gonyleptidae	e, h	5	P	P
Mi. i.	*Mitogoniella indistincta* Mello-Leitão, 1936	555	Gonyleptidae	c, e, j, l	21	P	P
Mi. m.	*Mitogoniella mucuri* Ázara et al., 2013	12	Gonyleptidae	a, d	2	P	P
Li. i.	*Liogonyleptoides inermis* (Mello-Leitão, 1922)	4	Gonyleptidae	i	1	A	P
Ps. m.	*Pseudopucrolia mutica* (Perty, 1833)	1	Gonyleptidae	d	1	A	P
Lo. t.	*Longiperna trembao* Pinto-da-Rocha & Bragagnolo, 2010	26	Gonyleptidae	c, e, j	5	P	P
Mi. 1	*Mitobatula* sp. 1	22	Gonyleptidae	a	2	P	P
Eu. a.	*Eusarcus aduncus* (Mello-Leitão, 1942)	24	Gonyleptidae	c, l	7	P	P
Eu. c.	*Eusarcus cavernicola* Hara & Pinto-da-Rocha, 2010	23	Gonyleptidae	m	1	P	A
Eu. 1	*Eusarcus* sp. 1	14	Gonyleptidae	e, j, l	6	P	P
Eu. 2	*Eusarcus* sp. 2	1	Gonyleptidae	f	1	-	-
Pl. 1	*Planiphalangodus* sp. 1	1	Gonyleptidae	a	1	P	A

Table 2. List of mines containing harvestmen, with the geographic coordinates (in decimal degrees, DATUM WGS 84), age (in years), use (not in use = D., daily tourism = D.T., mineral extraction = M.E., scientific experiment = S.E., sparse tourism = S.T., sparse visitation = S.V., urban zone = U.Z.), type of the surrounding vegetation/rock (Atlantic Forest = A.F., *Eucalyptus* forest = E., pasture = P., ferriferous formations = R.F.) on a 30 m (S. 30 m) and 250 m radius (S. 250 m), extension and identified harvestmen species (see Table 1 for species abbreviations).

Municipality	Mine	Latitude	Longitude	Age	Usage	S. 30 m	S. 250 m	Extension	Species
Alagoa	Mina da Companhia	-22.17812	-44.70546	> 100	S.T.	A.F.	P. - A.F.	46	*Mi.* 1, *Pl.* 1

Municipality	Mine	Latitude	Longitude	Age	Usage	S. 30 m	S. 250 m	Extension	Species
Alagoa	Túnel do Garrafão	-22.18221	-44.71956	> 100	S.T.	A.F.	P. - A.F.	73	*Mi. m.*, *Mi.* 1
Caeté	Mina do Morro Vermelho I	-19.96525	-43.71271	< 30	S.V.	E.	P. - E.	76	*Mi. i.*
Caeté	Mina do Morro Vermelho II	-19.96520	-43.71364	< 30	S.V.	E.	P. - E.	12	*Pa. 1*, *Eu. a.*
Caeté	Mina do Morro Vermelho III	-19.96538	-43.68757	< 30	S.V.	E.	P. - E.	60	*Mi. i.*, *Mi.* 1
Caeté	Mina dos Matarelli	-19.94719	-43.74017	< 50	D.	E.	P. - E - A.F.	62	*Lo. t.*
Caraí	Túnel da Br116	-17.22967	-41.49569	< 5	D.	P.	P.	8	*Ps. m.*
Caraí	Túnel do Noel I	-17.11623	-41.51527	< 5	M.E.	P.	P.	69	*Gr. p.*
Caraí	Túnel do Noel II	-17.11727	-41.51627	< 5	M.E.	P.	P.	38	*Gr. p.*
Caraí	Túnel da Fazenda Cilindro I	-17.11920	-41.32715	< 20	D.	P.	P.	10.2	*Mi. m.*
Mariana	Mina dos Canelas Casa	-20.35245	-43.43990	> 100	S.V.	R.F.	P.	49	*Go. v.*, *Eu.* 1
Mariana	Minas dos Canelas VI	-20.35315	-43.44090	> 100	S.V.	R.F.	R.F.	68	*Go. v.*
Mariana	Mina dos Canelas VII	-20.54384	-43.81015	> 100	S.V.	R.F.	R.F.	229	*Go. v.*, *Lo. t.*, *Eu.* 1
Mariana	Mina dos Canelas XI	-20.35256	-43.43936	> 100	S.V.	R.F.	R.F.	68	*Go. v.*, *Mi. i.*
Mariana	Mina dos Canelas XII	-20.35377	-43.43932	> 100	S.V.	R.F.	R.F.	98	*Go. v.*, *Mi. i.*
Mariana	Mina do Meio do Mato	-20.34518	-43.44805	> 100	S.V.	R.F.	R.F.	28	*Mi. i.*
Mariana	Mina da Cachoeira	-20.34507	-43.44678	> 100	S.V.	R.F.	R.F.	26	*Mi. i.*, *Eu.* 1
Mateus Leme	Mina do Aqueduto I	-19.95938	-44.42231	> 100	S.V.	R.F.	R.F.	11	*Eu.* 2
Mateus Leme	Mina do Aqueduto II	19.959223	-44.42196	> 100	S.V.	R.F.	R.F.	8	*Sp.* 1
Medina	Mina da Fazenda do Sol V	-16.34362	-41.45138	< 30	D.	P.	P.	27	*Ab. b.*
Medina	Mina da Fazenda Serra Azul I	-16.20885	-41.47934	< 30	D.	P.	P.	14	*Gr. p.*
Medina	Mina da Fazenda Serra Azul II	-16.21157	-41.47938	< 30	D.	P.	P.	74	*Gr. p.*
Medina	Mina do Bloco I	-16.21425	-41.46832	< 30	D.	P.	P.	126	*Ab. b.*, *Gr. p.*
Medina	Mina do Bloco II	-16.21610	-41.46872	< 30	D.	P.	P.	56	*Ab. b.*, 2
Medina	Mina do Bloco III	-16.21460	-41.46815	< 30	D.	P.	P.	31	*Ab. b.*, 2
Nova Lima	Mina de Capão Xavier	-20.0469	-43.9798	<5	S.C/ S.V.	R.F.	R.F>	15	*Go. v.*

Municipality	Mine	Latitude	Longitude	Age	Usage	S. 30 m	S. 250 m	Extension	Species
Novo Oriente de Minas	Mina do João Bufinha	-17.4137	-41.2097	-	S.V.	P.	P.	-	*Li. i.*
Ouro Preto	Mina da Volta do Córrego	-20.37922	-43.51066	> 100	S.V.	A.F.	A.F. - P.	22	*Go. c.*
Ouro Preto	Mina de Vila Rica	-20.38757	-43.49346	> 100	D.T.	U.Z.	U.Z.	96	*Lo. t.*
Ouro Preto	Mina do Chico Rei	-20.38608	-43.49930	> 100	D.T.	U.Z.	U.Z.	157	*Mi. i.*, *Lo. t.*, *Eu.* 1
Ouro Preto	Mina Velha	-20.38838	-43.49163	> 100	D.T.	U.Z.	U.Z.	174	*Mi. i.*
Padre Paraiso	Túnel dos Meninos I	-17.06916	-41.46849	< 20	D.	P.	P.	42	*Gr. p.*
Padre Paraiso	Túnel dos Meninos II	-17.06856	-41.46903	< 20	M.E.	P.	P.	29.8	*Gr. p.*
Padre Paraíso	Túnel do Hotel Entre Vales I	-17.06380	-41.48198	< 20	D.	P.	P. - A.F.	12.5	*Gr. p.*
Padre Paraíso	Túnel do Hotel Entre Vales II	-17.06380	-41.48198	< 20	D.	P.	P. - A.F.	39	*Gr. p.*
São José da Safira	Mina do Chiá Donizete I	-18.29455	-42.18781	< 50	D.	A.F.	A.F.	72	*Mi. i.*, *Eu. a.*
São José da Safira	Mina do Chiá Donizete II	-18.29064	-42.18758	< 50	M.E.	A.F.	A.F.	68	*Mi. i.*, *Eu. a.*
São José da Safira	Mina do Chiá Donizete III	-18.29163	-42.18846	< 50	D.	A.F.	A.F.	15.5	*Mi. i.*, *Eu. a.*
São José da Safira	Mina do Milto Godinho I	-18.29614	-42.18276	< 50	M.E.	P.	P.	33	*Eu. a.*
São José da Safira	Mina do Milto Godinho II	-18.29631	-42.18286	< 50	D.	P.	P.	12	*Mi. i.*
São José da Safira	Mina do Milto Godinho III	-18.29639	-42.18329	< 50	D.	P.	P.	52	*Mi. i.*, *Eu.* 1
São José da Safira	Mina do Milto Godinho IV	-18.29598	-42.18292	< 50	M.E.	P.	P.	72	*Mi. i.*, *Eu. a.*
São José da Safira	Mina do Milto Godinho VII	-18.29697	-42.18121	< 50	D.	P.	P.	37	*Mi. i.*
São José da Safira	Mina do Milto Godinho VIII	-18.29447	-42.18075	< 50	D.	P.	P.	84	*Mi. i.*, *Eu. a.*
São José da Safira	Túnel do Milto Godinho IX	-18.29395	-42.18040	< 50	D.	A.F.	P. - A.F.	12	*Mi. i.*
São José da Safira	Túnel do Milto Godinho X	-18.29268	-42.18421	< 50	D.	A.F.	P. - A.F.	67.6	*Mi. i.*
São José da Safira	Túnel do Milto Godinho XI	-18.29268	-42.18421	< 50	D.	A.F.	P. - A.F.	31	*Mi. i.*
São José da Safira	Túnel do Milto Godinho XII	-18.29292	-42.18485	< 50	D.	A.F.	P. - A.F.	48.5	*Mi. i.*, *Eu.* 1
São José da Safira	Túnel do Milto Godinho XIII	-18.29250	-42.18418	< 50	D.	A.F.	P. - A.F.	100.3	*Mi. i.*
Vazante	Mina da Vmetais	-17.95928	-46.82371	< 30	S.V.	P.	P.	600	*Eu. c.*

The mines with the highest number of species were Mina dos Canelas VII in Mariana, and Mina Turística do Chico Rei in Ouro Preto, each with 3 species (Table 2). All other cavities had only 1 or 2 species.

Species from mines with behavioral observations

Suborder Eupnoi Hansen & Sørensen, 1904
Family Sclerosomatidae Simon, 1879
Gagrellinae Thorell 1889

Abaetetuba bahiensis (Mello-Leitão, 1931)

Previously known distribution. Bahia: Ilhéus (Mello-Leitão 1931), Itamajarú, Juçari; Espírito Santo: Colatina (Tourinho-Davis 2004).

Examined material. *Medina*: 1 female (ISLA 16035) from Mina da Fazenda do Sol V (50), 08/IV/2009; 1 male (ISLA 16048) from Mina do Bloco I (8), 14/VII/2009; 1 male (MNRJ 2336) from Mina do Bloco II (5), 18/VII/2009; 1 male (ISLA 16030) from Mina do Bloco III (3), 14/VII/2009, new record for locality.

This species was observed forming aggregations of 8, 19 and 26 individuals at a maximum distance of 5 meters from the entrance representing the first record of an aggregation behavior for this species. In other cavities, sparsely distributed individuals were observed, but always located in the photic zone no more than 10 meters from the entrance. These records represent a new occurrence of this species for this municipality, thus expanding its distribution with 250 km from the southwest of Juçari, Bahia state.

Suborder Laniatores Thorell, 1876
Cosmetidae Koch, 1839
Discosomaticinae Pickard-Cambridge, 1905

Gryne perlata Mello-Leitão, 1936

Figure 3A–B

Previously known distribution. Pernambuco: municipality not specified (Mello-Leitão 1936).

Examined material. *Caraí*: 1 male (ISLA 16033) from Túnel do Noel I (1), 13/VII/2008; 1 female (MNRJ 2270) from Túnel do Noel II (3), 13/VII/2008; *Medina*: 2 males and 1 female (ISLA 16025) from Mina da Fazenda Serra Azul I (2400), 16/VII/2009; 1 male (ISLA 16036) from Mina da Fazenda Serra Azul II (2420), 16/VII/2009; 1 male (ISLA 16041) from Mina do Bloco I (28), Mina do Bloco II (218), 14/VII/2009, 1 male (ISLA 16029) from Mina do Bloco III (4), 14/VII/2009. *Padre Paraíso*: 1 male (ISLA 16037) from Túnel dos Meninos I (148), 12/VII/2008; 2 males

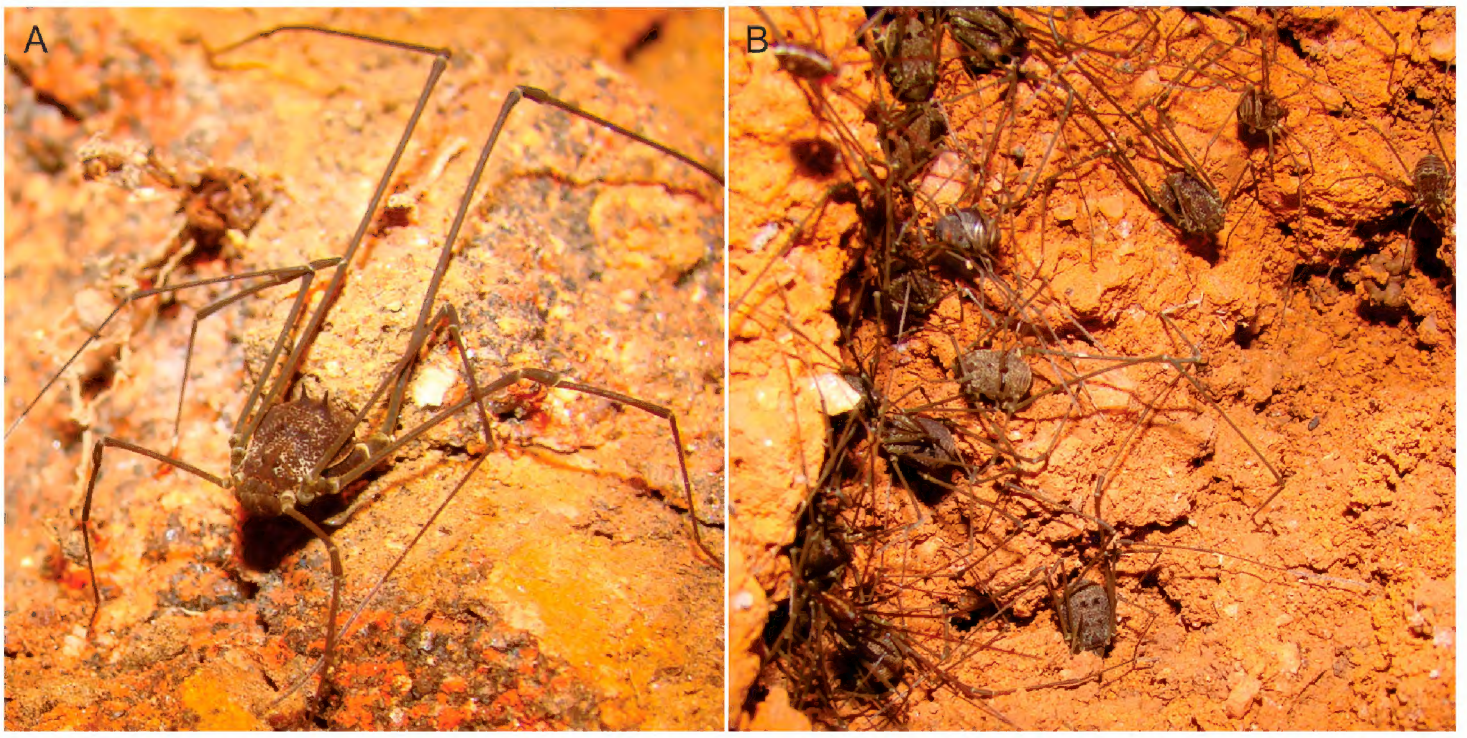

Figure 3. *Gryne perlata* **A** Individual inside the mine Túnel dos Meninos II, Padre Paraíso **B** aggregation of individuals in the same cavity.

and 1 female (ISLA 16028) from Túnel dos Meninos II (49), 12/VII/2008; 2 males and 1 female (ISLA 16031) from Túnel do Hotel Entre Vales I (9), 22/VII/2008; 1 male (ISLA 16034) from Túnel do Hotel Entre Vales II (18), 22/VII/2008, new record for state and localities.

This species was observed forming aggregations of 28, 45, 49, 103, 200, 400 and 2200 individuals at the entrance of seven cavities at a maximum distance of 5 m from the entrance. This was the first record of an aggregation behavior for this species. In other cavities, sparsely distributed individuals were also recorded, but always located in the photic zone at a maximum distance of 10 m from the entrance. During one of the fieldtrips, three aggregations with about 1000 individuals were observed. These aggregations were found in the epigean environment, next to the mine Túnel do Hotel Entre Vales I in holes and cracks in a ravine of exposed soil. Such shelters had a longitudinal form of ~ 80 cm in depth, 20 cm width and 1.5 cm height. The three municipalities represent new occurrences for this species, expanding its distribution ~ 1000 km from the south of Pernambuco state.

Family Cryptogeobiidae Kury, 2014

Paratricommatus sp. 1

Previously known distribution of the genus. Alto Paraná (Paraguai), Espírito Santo, Rio de Janeiro and São Paulo (Mello-Leitão 1940, Piza Jr 1943, H. Soares 1945, 1966, Soares and Soares 1946, 1954, 1985, H. Soares 1966, Kury 2014).

Examined material. *Caeté*: 1 female (MNRJ 2266) from Mina do Morro Vermelho II (1), 19/VI/2009, new record for state and locality.

Only one female was found. This is a new occurrence in the municipality, expanding the genus distribution with about 300 km from the southwest of Colatina, Espírito Santo state.

Spinopilar sp. 1

Previously known distribution of the genus. Alto Paraná (Paraguai), Argentina (province not specified), Espírito Santo, Minas Gerais, Rio de Janeiro, Santa Catarina (Sørensen 1932, Mello-Leitão 1940, Soares and Soares 1946, Roewer 1949, Soares 1972, Soares et al. 1985, Kury 1992, Acosta and Maury 1998, Kury and Pérez-González 2008).

Examined material. *Mateus Leme*: 1 female (MNRJ 2263) from Mina do Aqueduto II (3), 05/IV/2008, new record for locality.

Only one female was found and Mateus Leme corresponds to a new occurrence for the genus.

Family Gonyleptidae Sundevall, 1833
Goniosomatinae Mello-Leitão, 1935

Goniosoma carum (Mello-Leitão, 1936)

Previous known distribution. Minas Gerais: Viçosa (Mello-Leitão 1936).

Examined material. *Ouro Preto*: 1 male (ISLA 1468) from Mina da Volta do Córrego (1), 13/VI/2009, new record for locality.

Ouro Preto corresponds to a new occurrence for this species, expanding its distributions with about 100 km from the northwest of Viçosa, Minas Gerais state.

Goniosoma vatrax Koch, 1848

Figure 4D

Previously known distribution. Minas Gerais: Catas Altas (DaSilva and Gnaspini 2010), Ouro Preto (Mello-Leitão 1932) and Santa Bárbara (Mello-Leitão 1936).

Examined material. *Mariana*: 1 male (ISLA 16019) from Mina dos Canelas Casa (4), 01/V/2009; 1 male (MNRJ 2339) from Minas dos Canelas VI (3), 02/V/2009; 1 female (ISLA 16020) from Mina dos Canelas VII (3), 11/VI/2009; 1 male (ISLA 9573) from Mina dos Canelas XI (2), 11/VI/2009; 1 male (ISLA 16047) from Mina dos Canelas XII (2), 11/VI/2009 (Bernardi et al. 2011); *Nova Lima*: 1 male (ISLA 160) from Mina de Capão Xavier (15), 10/V/2009, new record for locality.

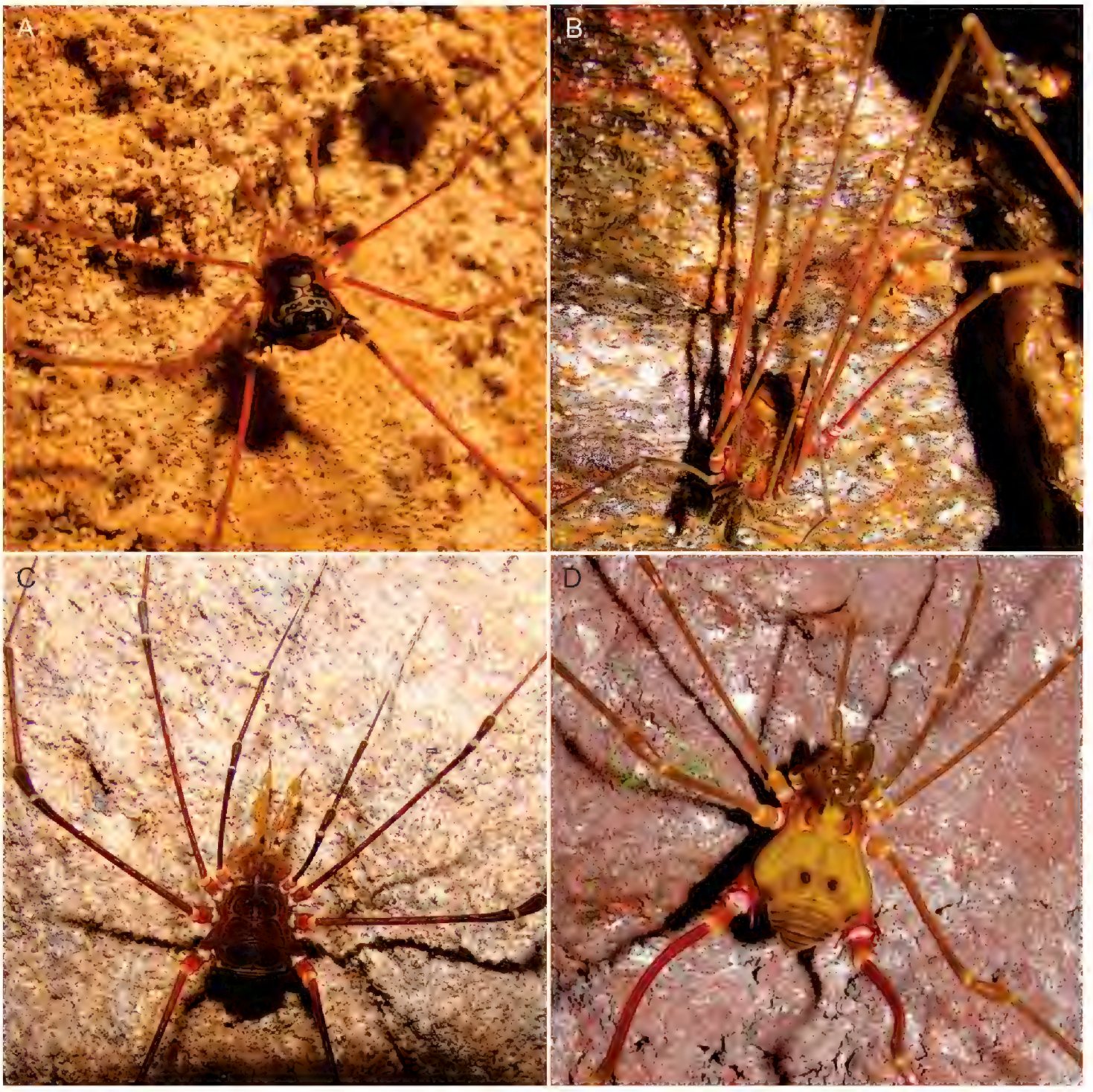

Figure 4. Individuals inside the artificial cavities **A** *Longiperna trembao* (Caeté: Mina dos Matarelli) **B** *Mitogoniella mucuri* (Alagoa: Túnel do Garrafão) **C** *Mitobatula* sp. 1 (Alagoa: Mina da Companhia) **D** *Goniosoma vatrax* (Nova Lima: Mina de Capão Xavier).

Sparse individuals were registered in the photic and aphotic zones of the mines at a maximum distance of 45 meters from the entrance. Nova Lima corresponds to a new occurrence for this species, expanding its distribution with about 40 km from the east of Santa Bárbara, Minas Gerais. However, the Mina de Capão Xavier was destroyed by the expansion of mining activities, and its fauna was translocated to another artificial mine constructed in the same region of the original one (Ferreira, R.L. pers. observation).

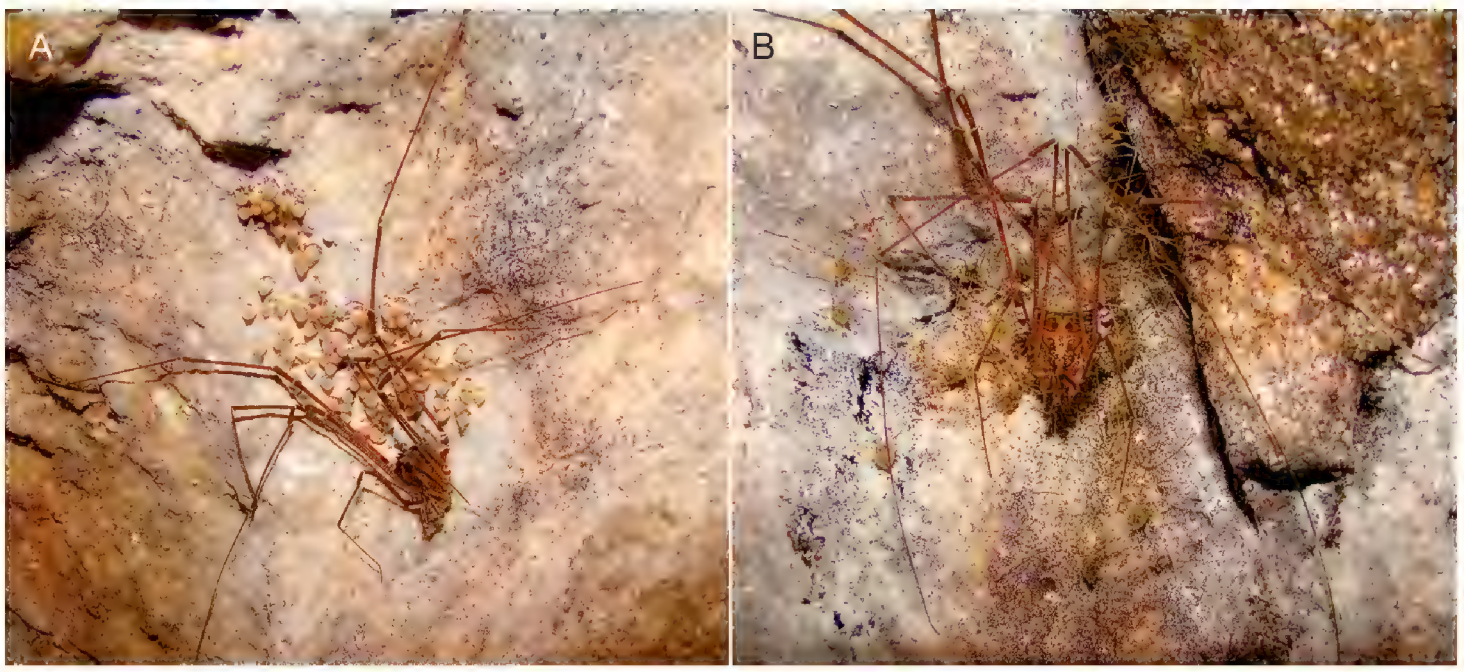

Figure 5. *Mitogoniella mucuri* inside the Túnel do Garrafão (Alagoa) **A** Female guarding eggs on the wall of the mine **B** Female guarding immatures on the wall of the mine.

Mitogoniella indistincta Mello-Leitão, 1936

Figure 5A–B

Previously known distribution. Minas Gerais: Alto Caparaó, Baependi, Barão de Cocáis (Ázara et al. 2013), Brumadinho (DaSilva and Gnaspini 2010), Caeté (Ázara et al. 2013), Catas Altas (DaSilva and Gnaspini 2010), Itabirito, Itambé do Mato Dentro (Ázara et al. 2013), Jaboticatubas (DaSilva and Gnaspini 2010), Lima Duarte, Mariana, Minduri, Ouro Branco, Ouro Preto, Prados (Ázara et al. 2013), Santa Bárbara (Mello-Leitão 1936), Santana do Riacho (DaSilva and Gnaspini 2010).

Examined material. *Caeté*: 1 female (ISLA 16038) from Mina do Morro Vermelho I (6), 17/VI/2009; 1 male (MNRJ 2337) from Mina do Morro Vermelho III (6), 17/VI/2009. *Mariana*: 1 male (ISLA 16057) from Mina dos Canelas XI (12), 11/VI/2009; 1 male (ISLA 1491) from Mina dos Canelas XII (6), 11/VI/2009; 1 male (ISLA 16022) from Mina do Meio do Mato (5), 12/VI/2009; 1 male (ISLA 16023) from Mina da Cachoeira (3), 12/VI/2009 (Ázara et al. 2013). *Ouro Preto*: 1 male (ISLA 16049) from Mina do Chico Rei (3), 29/XI/2009; 1 male (ISLA 16053) from Mina Velha (6), 29/XI/2009 (Bernardi et al. 2010). *São José da Safira*: 1 male (ISLA 16027) from Mina do Chiá Donizete I (78), 13/VII/2009; 1 male (ISLA 9575) from Mina do Chiá Donizete II (39), 13/VII/2009; 1 male (ISLA 9577) from Mina do Chiá Donizete III (5), 13/VII/2009; 1 male (ISLA 16050) from Mina do Milto Godinho II (5), 11/VII/2009; 1 male (ISLA 16051) from Mina do Milto Godinho III (34), 11/VII/2009; 1 male (ISLA 16052) from Mina do Milto Godinho IV (17), 11/VII/2009; 1 male (ISLA 9576) from Mina do Milto Godinho VII (84), 12/VII/2009; 1 male (MNRJ 2340) from Mina do Milto Godinho VIII (47), 12/VII/2009; 1 male (ISLA 16054) from Túnel do Milto Godinho IX (1), 12/VII/2009; 1 male (ISLA 16055) from Túnel do Milto Godinho X (38), 12/VII/2009; 1 male (ISLA 3690) from Túnel do Milto Godinho XI (48), 21/VII/2009; 1 male (ISLA 9572) from Túnel do Milto

Godinho XII (51), 12/VII/2009; 1 male (ISLA 16056) from Túnel do Milto Godinho XIII (71), 12/VII/2009 (Ázara et al. 2013).

In seven cavities, this species was observed forming aggregations of 10, 15, 18, 22, 41 and 43 individuals up to 5 meters from the entrance. In other cavities, sparsely distributed individuals were also recorded both in the photic and aphotic zones at a maximum distance of 60 m from the entrance. In some cases, individuals were found guarding their eggs and nymphs. This species also occurs in natural cavities in Minas Gerais State (Machado 2002, DaSilva and Gnaspini 2010, Ázara et al. 2013)

Mitogoniella mucuri Ázara et al., 2013

Figure 5A–B

Previously known distribution. Minas Gerais: Alagoa, Caraí, Novo Oriente de Minas, Padre Paraíso (Ázara et al. 2013).

Examined material. *Alagoa*: 1 male (ISLA 3983) from Túnel do Garrafão (10), 31/VIII/2008 (Ázara et al. 2013). *Caraí*: 1 male (ISLA 3970) from Túnel da Fazenda Cilindro I (2), 21/VII/2008 (Ázara et al. 2013).

Individuals of this species were recorded sparsely distributed inside the mines both in the photic and aphotic zones at a maximum distance of 36 m from the entrance. In some mines, specimens were found guarding their eggs and nymphs. This species also occurs in natural cavities in Minas Gerais state (Ázara et al. 2013).

Gonyleptinae Sundevall, 1833

Liogonyleptoides inermis (Mello-Leitão, 1922)

Previously known distribution. Minas Gerais: Tapira (H. Soares 1977); Rio de Janeiro: Petrópolis (Mello-Leitao 1923); Santa Catarina: Mafra (Mello-Leitão 1937); São Paulo: Santo André (Mello-Leitao 1922), Amparo, Anápolis (B. Soares 1945b), Barretos (Mello-Leitão 1937), Cascalho, Corumbataí (B. Soares 1945c), Espírito Santo do Pinhal (H. 1966), Funil (B. Soares 1946), Guaianaz (B. Soares 1945b), Laranja Azeda (Soares and Soares 1945), Lusitânia (B. Soares 1945c), Mogi Guaçu (H. Soares 1966), Piracicaba (B. Soares 1946), Rio Claro (B. Soares 1945a), Santa Adélia (H. Soares 1966), São Paulo (B. Soares 1945c), Silvânia (B. Soares 1946), Vista Alegre do Alto (H. Soares 1977).

Examined material. *Novo Oriente de Minas*: 1 male (MNRJ 2338) from Mina do João Bufinha (4), 05/I/2009, new record for locality.

Individuals were sparsely distributed inside the mines, both in the photic and aphotic zones at a maximum distance of 10 m from the entrance. Novo Oriente de Minas corresponds to a new occurrence for this species, expanding its distribution with about 700 km from the northeast of Petrópolis, Rio de Janeiro state.

Heteropachylinae Kury, 1994

***Pseudopucrolia mutica* (Perty, 1833)**

Previously known distribution. Bahia: Salvador (Roewer 1912), municipality not specified (Mello-Leitao 1926); Pernambuco: Arquipélago de Fernando de Noronha (Roewer 1930), Tapera (Mello-Leitão 1927); Sergipe: Aracaju, Maroim, Santo Amaro das Brotas (Soares and Bauab-Vianna 1972); São Paulo: municipality not specified (Roewer 1913).

Examined material. *Caraí*: 1 male (MNRJ 2271) from Túnel da Br116 (1), 20/VII/2008, new record for state and locality.

Only one individual was recorded in the photic zone of the cavity, at less than 10 m from the entrance. The record at Caraí expands the distribution of this species with about 750 km from the southwest of Salvador, Bahia.

Mitobatinae Simon, 1879

***Longiperna trembao* Pinto-da-Rocha & Bragagnolo, 2010**
Figure 4A

Previously known distribution. Minas Gerais: Belo Horizonte, Ouro Preto (Pinto-da-Rocha and Bragagnolo 2010).

Examined material. *Caeté*: 1 male (ISLA 16059) from Mina do Morro Vermelho III (1), 17/VI/2009; 1 male (MNRJ 2269) from Mina dos Matarelli (11), 18/VII/2009. *Mariana*: 1 male (ISLA 16060) from Mina dos Canelas VII (3), 11/VI/2009. *Ouro Preto*: 1 male (ISLA 16058) from Mina de Vila Rica (2), 28/XI/2009; 1 male (MNRJ 2268) from Mina do Chico Rei (9), 27/XI/2009, new records for localities.

Individuals of this species were sparsely distributed in the photic and aphotic zones of the mine at a maximum distance of 30 m from the entrance. The records at Caeté and Mariana expand its distribution with about 60 km from the northwest of Ouro Preto, Minas Gerais state.

***Mitobatula* sp. 1**
Figure 4C

Previously known distribution of *Mitobatula castanea* Roewer, 1931 (the genus is monospecific). Santa Catarina: Serra Azul (Roewer 1931); Rio de Janeiro: Teresópolis (Kury 2003).

Examined material. *Alagoa*: 1 male (MNRJ 2374) from Mina da Companhia (7), 01/XI/2008; 1 male (MNRJ 2342) from Túnel do Garrafão (15), 31/X/2008, new record for state and locality.

Individuals of this morphospecies were sparsely distributed in the photic and aphotic zones at a maximum distance of 12 m from the entrance. The record at Alagoa expands the distribution of the genus with about 150 km from the west of Teresópolis, Rio de Janeiro state.

Pachylinae Sørensen, 1884

***Eusarcus aduncus* (Mello-Leitão, 1942)**

Previously known distribution. Bahia: Carinhanha, Itagibá, Una (Hara and Pinto-da-Rocha 2010); Distrito Federal: Brasília, Brazlândia (Hara and Pinto-da-Rocha 2010); Espírito Santo: Barra do São Francisco (Hara and Pinto-da-Rocha 2010), Colatina (Mello-Leitão 1942), Linhares (Hara and Pinto-da-Rocha 2010); Goiás: Corumbá (Hara and Pinto-da-Rocha 2010), Formosa (Gnaspini and Trajano 1994), Itaberaí, Mabaí (Hara and Pinto-da-Rocha 2010), São Domingos (Trajano and Gnaspini 1991); Minas Gerais: Itacarambi (Chaimowicz 1986).

Examined material. *Caeté*: 1 male (MNRJ 2265) from Mina do Morro Vermelho II (2), 19/VI/2009. *São José da Safira*: 2 males (ISLA 16026) from Mina do Chiá Donizete I (10), 13/VII/2009; 1 female (ISLA 16042) from Mina do Chiá Donizete II (1), 11/VII/2009; 1 female (ISLA 16043) from Mina do Chiá Donizete III (1), 11/VII/2009; 1 male (MNRJ 2267) from Mina do Milto Godinho I (2), 11/VII/2009; 1 female (ISLA 16044) from Mina do Milto Godinho IV (4), 11/VII/2009; 1 male (MNRJ 2377) from Mina do Milto Godinho VIII (4), 11/VII/2009, new record for localities.

Individuals of this species were found sparsely distributed in the photic and aphotic zones at a maximum distance of 60 m from the entrance. The records at Caeté and São José da Safira expand its distribution with about 100 km from the south of Carinhanha, Bahia. This species also occurs in Minas Gerais and São Paulo state in natural cavities (Chaimowicz 1986, Trajano and Gnaspini 1991, Gnaspini et al. 1994, Hara and Pinto-da-Rocha 2010).

***Eusarcus cavernicola* Hara & Pinto-da-Rocha, 2010**

Previously known distribution. Bahia: Santana; Goiás: Anápolis, São Domingos; Minas Gerais: Itacarambi, Montes Claros, Unaí (Hara and Pinto-da-Rocha 2010).

Material examined. *Vazante*: 1 male (MNRJ 2344) from Mina da Vmetais, 08/IV/2009, new record for locality.

Individuals of this species were observed sparsely distributed inside the mine. They were located in the photic and aphotic zones at a maximum distance of 500 m from the entrance. The record at Vazante expands its distribution with about 200 km from the south of Unaí, Minas Gerais. This species also occurs in natural cavities in Bahia, Goiás and Minas Gerais state (Hara and Pinto-da-Rocha 2010).

Eusarcus sp. 1

Previously known distribution of the genus. From the northeast to the southeast of Brazil, northeast of Argentina, east of Paraguai and Uruguai (Hara and Pinto-da-Rocha 2010).

Examined material. *Mariana*: 1 male (ISLA 16061) from Mina dos Canelas I (1), 11/VI/2009; 1 male (ISLA 16021) from Mina dos Canelas VII (2), 11/VI/2009; 1 male (ISLA 16024) from Mina da Cachoeira (4), 12/VI/2009 (Bernardi et al. 2011). Ouro Preto: 1 female (ISLA 16045) from Mina do Chico Rei (3), 02/V/2009 (Bernardi et al. 2010). *São José da Safira*: 1 male (MNRJ 2376) from Mina do Milto Godinho III (2), 13/IV/2009; 1 male (ISLA 16018) from Túnel do Milto Godinho XII (2), 12/IV/2009, new record for locality.

Individuals were observed sparsely distributed inside the cavities both in the photic and aphotic zones, at a maximum distance of 22 m from the entrance. Individuals were also observed next to the touristic path. The records at Mariana and São José da Safira correspond to new occurrences for the genus.

Eusarcus sp. 2

Previoulys known distribution of the genus. From the northeast to the southeast of Brazil, northeast of Argentina, east of Paraguai and Uruguai. (Hara and Pinto-da-Rocha 2010).

Examined material. *Mateus Leme*: 1 male (ISLA 16062) from Mina do Aqueduto I (1), 05/IV/2008, new record for locality.

Only one female was found and the record of Mateus Leme corresponds to a new occurrence for this genus.

Planiphalangodus sp. 1

Previously known distribution of *Planiphalangodus robustus* Roewer, 1929 (the genus is monospecific). Santa Catarina: municipality not specified (Roewer 1929); Argentina, Missiones: *Iguazú* (Ringuelet 1959).

Examined material. *Alagoa*: 1 male (MNRJ 2264) from Mina da Companhia (1), 01/XI/2008, new record for state and locality.

Only one male was found and the record of Alagoa corresponds to a new occurrence for this genus.

Discussion

This study presented the occurrence of two undescribed species (*Eusarcus* sp. 1 and *Mitobatula* sp. 1) and new records for states and localities in the case of nine species and

four genera of harvestmen. The results obtained demonstrate the importance of observations in unusual environments, like mines for the potential of finding new species, provide more information about the occurrence of species and register new behavioral patterns, thus improving the knowledge about the group.

Although there are studies in Brazil and worldwide about the fauna associated to mines (Peck 1988, Gnaspini and Trajano 1994, Ferreira 2004, Bernardi et al. 2010, 2011, Isaia et al. 2011), most of them are focused on community ecology. Until present only few groups received special attention in studies of mines: anurans (Rosa and Penado 2013), bats (Kurta and Smith 2014) and salamanders (Manenti et al. 2009, Manenti and Ficetola 2013, Balogová and Uhrin 2014, Herrero and Hinckley 2014).

The only record of harvestmen in artificial subterranean environments outside the state of Minas Gerais was for the species *Pararezendesius luridus* H. Soares, 1972, which was found in mines of Iporanga and also in natural cavities of Apiaí, Iporanga and Ribeira municipalities, São Paulo state (Soares 1972, Trajano et al. 1991, Gnaspini et al. 1994, Pinto-da-Rocha 1995). Three species, *Eusarcus* sp. 1, *Goniosoma vatrax* and *Mitogoniella indistincta,* were recorded in touristic mines of Mariana and Ouro Preto, Minas Gerais state (Bernardi et al. 2010, 2011).

The age of the majority of the mines in our study varied from less than five years to more than 100 years (Table 2). Twenty of the 52 cavities containing harvestmen have only pastures surrounding them (30 and 250 m radius). The other cavities present different phytophysiognomies arround them, such as Atlantic Forest, Caatinga and Cerrado fragments, *Eucalyptus* plantations and pastures.

As shown by Bragagnolo et al. (2007), richness and abundance of harvestmen species in the Atlantic Forest are negatively affected by fragmentation, reduction of fragment size and forest quality (stratification and leaf density). The replacement of natural environments by areas with mineral exploitation can destroy the habitats. However, mines apparently might ensure the permanence for a number of species that otherwise might get locally extinct through the destruction of epigean habitats (Ferreira 2004). However, it is still unknown how populations inside mines surrounded by pastures and small fragments can maintain.

The results of this work show that harvestmen can use mines as shelters during the day and for reproduction. These mines are important because many of the studied regions are fragmented, with forest areas replaced by pastures and agricultural land. Future studies can demonstrate whether harvestmen feed in the pastures or use the organic material inside the mines.

The presence of *Eusarcus cavernicola* individuals, a species commonly found in caves (Hara and Pinto-da-Rocha 2010), inside of the mine Mina da Vmetais (500 m from the entrance) suggests that this habitat is a permanent shelter for the species, due the presence of the food resource in the cavity.

Further studies should be concentrated on understanding the dynamics of species inside mines and the taxonomic identification. Artificial cavities can contribute to the conservation of some harvestmen species in many areas where the original vegetation was removed and replaced by pastures, monocultures or constructions.

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